Collimated Bisecting Acoustic Beam Conduction Velocity and Scattering Analysis for Faster and More Accurate Blood Pressure Measurement

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Introduction

The study of blood pressure is an important diagnostic tool in a variety of contexts, be it for managing chronic hypertension, assessing hypovolemia or in identifying acute hypertension in preeclampsia.

The concept of squeezing someone's arm and measuring blood pressure by measuring the time it takes for the arteries to push back sufficiently to push trapped air from one balloon into another is an incredibly antiquated and inaccurate means of assessing blood pressure.

A faster and more accurate method for assessing blood pressure would be beneficial to the practice of medicine.

Abstract

One of the chief problems with measuring blood pressure by squeezing an arm is that it does not take into account the effects produced by the musculature. More musculature tends to result in the blood vessels having less effect upon the ballon, creating the illusion of lower blood pressure. Doctors see no problem with this as they believe that physical exercise lowers blood pressure but do not take into account the possibility that this is an illusion created by the presence of increased musculature. Doctors also believe that exercise causes blood pressure to increase transiently during physical exercise. Again, this may well be an illusion created by increased pulse rate. The more times blood vessels pulse during a blood pressure test, the more the ballon is going to inflate, naturally.

Acoustic energy can be used to assess the density of any object and is already used in medical testing in the context of certain liver cirrhosis tests. Acoustic energy can, therefore, be used to measure the density of fluid moving through a blood vessel.

Measuring the acoustic-conductive properties of the entire width of someone's arm or wrist would not be useful as the presence of other tissues and variability in the diameter of various blood vessels would make it difficult to obtain a baseline for blood vessel width. A single blood vessel must be isolated in order to produce an accurate reading using this method.

A device may be affixed to a person's wrist which is capable of directing collimated acoustic energy from a variety of directions whereas a primary beam and a secondary beam are utilized in order to deliberately de-collimate the primary beam at a variety of spatial points in the wrist. The largest artery would be isolated by looking for abrupt changes relative to the estimated point of beam bisection to overall scattering of the detected beam. As wave-

scattering increases exponentially over distance but proportionally in response to increased density, the increased scattering effects associated with a purposefully de-collimated beam would behave, functionally, precisely as would the ability to implant an acoustic emitter deep into the tissues of the wrist without the complications involved in so doing. This would allow for the position of the “rear” of the artery to be found relative to the source of emission of the primary beam as scattering could be predicted to abruptly drop off when the point of bisection surpasses the fluidic contents of that artery. The “front” could be found by repeating the process in reverse by emitting acoustic energy in the opposite direction and employing a detector on the opposite side, whereas the mechanism would consist of a ring of acoustic emitters and detectors.

If a de-collimating distortion caused by interaction with transverse acoustic energy occurs prior to the primary beam reaching the boundary of the artery, the beam will predictably de-collimate to a far greater degree in conjunction with the scattering effects of the fluidic contents of the artery, much as a prism would cause light to be diffused to a greater degree when used in conjunction with a second prism. The collimated beam would be designed to resist scattering to the greatest extent possible, but the transverse beam would be designed to spoil the properties which make the collimated beam resistant to scattering. Naturally, the scattering effects are greater in fluids of higher density and thus, this allows us to differentiate between blood and other tissues such as the walls of the artery and, say, musculature and water content of the wrist, as a whole.

Once the spatial boundaries of the artery are established, a useful measurement of pressure may be taken by measuring the velocity at which acoustic energy is carried across the fluids in the artery.

If a pulse of acoustic energy is emitted through the primary beam at time “X” and the de-collimating pulse is emitted at time “Y,” and blood-associated levels of scattering cease to be detected at a certain point, with the precise diameter of the vessel being known and the conductive velocity of acoustic energy through blood at varying blood pressures being programmed into the device, we can infer the precise blood pressure from the effect upon velocity that a given volume of blood has upon the acoustic energy of the primary beam. That velocity would affect, in a predictable manner, the needed aim-point (and/or firing time) for the secondary beam in order to find a mitigated scattering condition. If we know how much time the primary beam spent traveling through the wrist prior to reaching the artery, after completing its passage through the artery and we, furthermore, know the diameter of the artery, then we can infer how fast the sound was moving during the portion of the journey which took it through the fluidic portion of the artery. As such, with a sufficiently sophisticated acoustic emission and detection system, we can selectively measure the pressure of blood in a single artery or other blood vessel.

Conclusion

Although the sensors and computational requirements would be substantial, there is no reason why a blood pressure reading couldn’t be taken in this

manner. The most challenging aspect would be accurately extrapolating the precise boundaries of the fluids carried within the primary artery through a type of “bruteforce” combination-guessing process. Knowing the position of the outer boundary of the artery would not be useful as we need to know the diameter of the fluidic content as we want only to measure the conductive velocity of sound through the fluidic contents in order to deduce pressure.

This system, if constructed, would allow for both systolic and diastolic readings of unprecedented speed and accuracy. The system may have applications beyond simple blood pressure readings such as the identification and location of tumors or arterial mapping with application for preventing accidental damage to unseen arteries during surgical procedures.